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Blood Vessel Segmentation in Angiograms using Fuzzy Inference System and Mathematical Morphology

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***Abstract*- Segmentation of blood vessels is one of the essential medical computing tools for clinical assessment of vascular diseases. It is a process of partitioning an angiogram into non overlapping vascular and background regions. Based on the partitioning results, surfaces of vasculatures can be extracted, modeled, manipulated, measured and visualized. Edge detection is an essential task in computer vision. It covers a wide range of application, from segmentation to pattern matching. Angiography is a widely used procedure for vessel observation in both clinical routine and medical research. Often for the subsequent analysis of the vasculature it is needed to measure the angiogram area covered by vessels and/or the vessel length. For this purpose we need vessel enhancement and segmentation. In this paper, we evaluate the performance of a fuzzy inference system and morphology filters for blood vessel segmentation in a noise angiograms image.**

***Keywords*- Segmentation, EdgeDetection, Fuzzy inference, Morphology**

I. INTRODUCTION

A. *Existing Technique:*

Conventionally edge is detected according to some early brought forward algorithms as follows:

i. Sobel algorithm
ii. Prewitt algorithm
iii. Laplacian of Gaussian operator.

B. *Disadvantages of Existing Technique:*

- They are not fit for noise medical image edge detection because noise and edge belong to the scope of high frequency.
- In real world applications, medical images contain object boundaries and object shadows and noise.
- They may be difficult to distinguish the exact edge from noise or trivial geometric features.

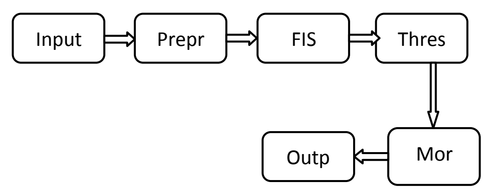
C. *Our proposed Technique:*

In this paper, we novel a fuzzy inference system and morphology filters for vessel edge detection or vessel segmentation.

D. *Advantages of our Technique:*

It is more efficient for segmentation of angiogram images and noise cancelling than other methods such as canny method.

Block Diagram:



Tools: MATLAB 7, and above.

i). Segmentation of blood vessels:

Segmentation of blood vessels is one of the essential medical computing tools for clinical assessment of vascular diseases. It is a process of partitioning an angiogram into nonoverlapping vascular and background regions. Based on the partitioning results, surfaces of vasculatures can be extracted, modeled, manipulated, measured and visualized. These are very useful and play important roles for the endovascular treatments of vascular diseases. Vascular diseases are one of the major sources of morbidity and mortality worldwide. Therefore, developing reliable and robust image segmentation methods for angiography has been a priority in our group and other research groups.

It is challenging to perform image segmentation in angiography. For example, blood vessels can contain low or complex flow. This can lead to low signal-to-noise (SNR) ratio in the angiograms. The conventional segmentation methods based on image intensity alone may then fail when there is a significant signal drop in the vascular region. Furthermore, the intensity inhomogeneity violates the intensity piecewise constant assumption in the segmentation process. Finally, the intensity contrast between vessel and background regions, or inside vessel regions can vary from region to region. Therefore, the local intensity statistics in the vessel and background regions may not be reliable, or the intensity gradient magnitude may not be large enough on the vessel boundary for the conventional image segmentation methods. Reviews on this topic can be found. This paper reports the image segmentation methods recently developed at Lo Kwee-Seong Medical Image Analysis Laboratory, The Hong Kong University of Science and Technology for detecting blood vessels in angiography.

ii) Edge detection:

Edge detection is an essential task in computer vision. It covers a wide range of application, from segmentation to pattern matching. It reduces the complexity of the image allowing more costly algorithms like object recognition, object matching, object registration, or surface reconstruction from stereo images to be used. Their detection is interesting for different goals. They can be used to measure parameters related to blood flow or to locate some patterns in relation to vessels in angiographic images. They can also be used as a first step before registration. Conventionally edge is detected according to some early brought forward algorithms like sobel algorithm, prewitt algorithm and Laplacian of Gaussian operator. But in theory they belong to the high pass filtering, which are not fit for noise medical image edge detection because noise and edge belong to the scope of high frequency. In real world applications, medical images contain object boundaries and object shadows and noise. Therefore, they may be difficult to distinguish the exact edge from noise or trivial geometric features. In this paper, we novel a fuzzy inference system and morphology filters for vessel edge detection or vessel segmentation.

Proposed System

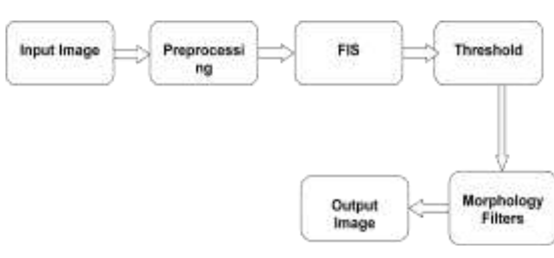


Fig 1: Blood vessel segmentation system.

II. IMAGE PROCESSING

During input image preprocessing stage, 4 linear filters were employed, as shown in Figure 2.1.

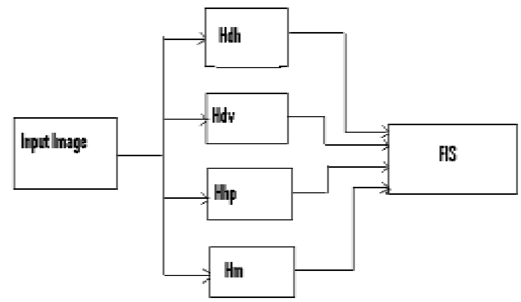


Fig 2.1: pre-processing system applied Sobel operators used to estimate the first derivative of Input image angiogram in horizontal and vertical directions. Hhp and Hm are kernels of High pass and Low pass filters

Sobel operators Hdh and Hdv are kernels with 3*3 elements given by

$$Hdh = \begin{bmatrix} 1 & 0 & 1 \\ 2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix}$$

$$Hdv = \begin{bmatrix} 1 & 2 & 2 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{bmatrix}$$

As a high-pass filter, we adopted also a 3x3 kernel, given by

$$Hhp = \begin{bmatrix} -1/16 & -1/8 & -1/16 \\ -1/8 & 3/4 & -1/8 \\ -1/16 & -1/8 & -1/16 \end{bmatrix}$$

Filter hM in turn, was chosen in such a way as to guarantee that the gray level in each pixel of the output image is the arithmetic mean of the gray levels in a 5x5 neighborhood of the same pixel in the input image. same pixel in the input image.

Hg is Gaussian filter and described by :

$Hg(x, y, z) = \exp(-(x^2 + y^2) / 2z^2)$, z=1

Given the kernels associated with each filter, the filtered images may be computed through a bi dimensional convolution operation:

DH = Hdh * I

DV = Hdv * I

HP = Hhp * I

G = Hg * I

III. Fuzzy Inference System:

What is Fuzzy Logic?

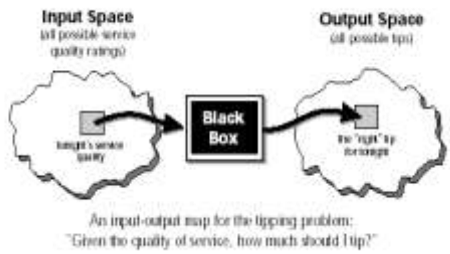


Fig 2.2 An input-output map for the tipping problem

Fuzzy Logic is a convenient way to map input space to output space.E.g., How much to tip at hotel? Input space is the quality of service and output space is the amount of tip.

i). Fuzzy Inference Systems

Fuzzy inference is the actual process of mapping from a given input to an output using fuzzy logic. The process involves all the pieces that we have discussed previously i.e., membership functions, fuzzy logic operators, and if-then rules.

Example:

We will see how everything fits together using the two-input (service, food) and one output(tip) three rule tipping problem.

Information flows from left to the right, from two inputs to a single output.

In the fuzzy logic toolbox, there are five parts of the fuzzy inference process:

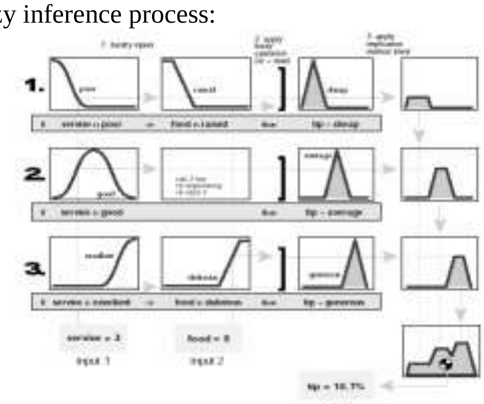


Fig 2.3 Fuzzy inference in tipping problem

Fuzzification of the input variables

The first step is to take the inputs and determine the degree to which they belong to each of the appropriate fuzzy sets via membership functions. The input is always a crisp numerical value limited to the universe of discourse of the input variable and the output is a fuzzy degree of membership (always in interval between 0 and 1).

Application of the fuzzy operator (AND or OR) in the antecedent

If the antecedent of a given rule has more than one part, the fuzzy operator is applied to obtain one number that represents the result of the antecedent for that rule. This number will then be applied to the output function. Any number of well-defined methods can fill in for the AND operation or the OR operation. In fuzzy logic toolbox, two built -in AND methods are supported: min (minimum) and prod (product). Two built-in OR methods are also supported: max(maximum), and the probabilistic OR method probor.

Implication from the antecedent to the consequent

The implication method is defined as the shaping of the consequent (a fuzzy set) based on the antecedent (a single number). The input for the implication process is a single number given by the antecedent, and the output is a fuzzy set. Implication occurs for each rule. Two built-in methods are supported, min (minimum) which truncates the output fuzzy set, and prod (product) which scales the output fuzzy set.

Defuzzification

Input for defuzzification phase is unified fuzzy set formed by aggregation of consequents and output is crisp number. If there are more than one output variables, final output for each variable is a crisp number. The most popular defuzzification method is the centroid calculation, which returns the center of area under the curve. There are five built-in methods supported: centroid, bisector, middle of maximum (the average of the maximum value of the output set), largest of maximum, and smallest of maximum.

III. RESULTS

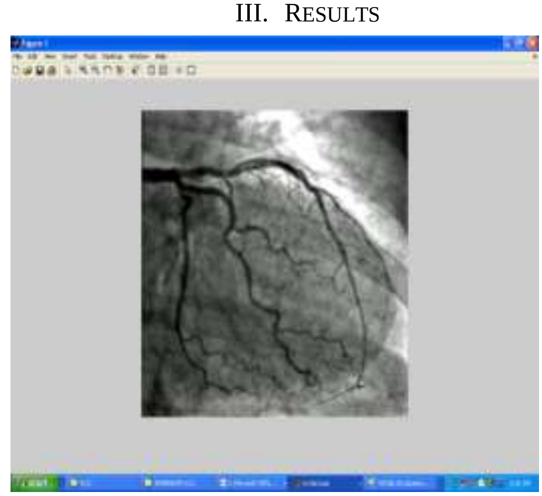


Fig 4.1 Input

The fig shows the original angiogram image which is given as input to preprocessing.

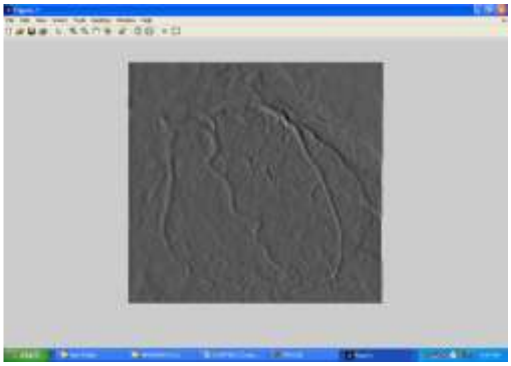


Fig4.2Output of Sobeloperator (horizontal

Fig 4.3 Output of high pass operator

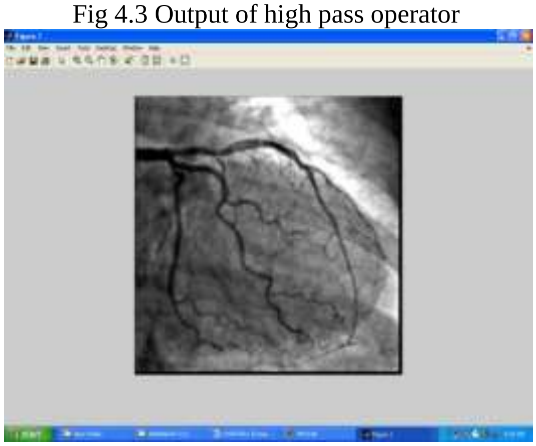


Fig 4.4 Output of Gaussian operator

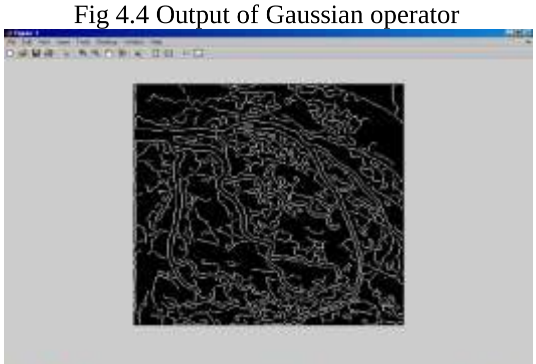


Fig 4.5 Output of Canny operator

Fig 4.5 shows the output of the previous method such as Canny operator with some noise.

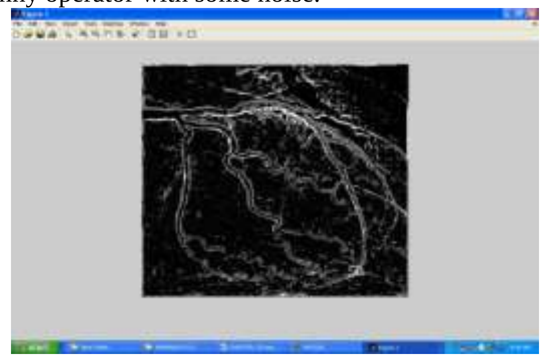


Fig 4.6 Output of FIS

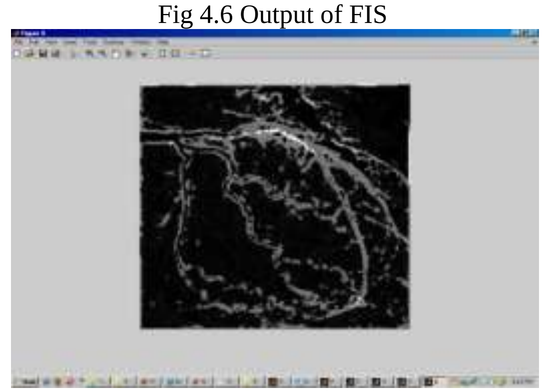


Fig 4.7 Output of Mathematical morphology

Fig 4.6 and Fig 4.7 shows the out put of FIS and Mathematical morphology which overcome the problem of Cannyoperator.

IV. Conclusion

In this paper, a novel fuzzy inference system and mathematical morphologic algorithms is proposed to segmentation of blood vessels. The results show that the algorithm is more efficient for segmentation of angiogram images and noise cancelling than other methods such as canny method.

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